FRED Reports

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1979 BROODYEAR COMPLETION REPORT:
A SIZE AT RELEASE STUDY

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ABSTRACT

Experimental groups of the 1979 brood spring chinook salmon released from Deer Mountain Hatchery (Ketchikan, Alaska) tested the efficacy of smolt size on ocean survival. Feed adjustments over a 14-month period produced groups of smolts averaging 13.4, 16.8, 18.0, and 24.6 g at release in May 1981. From 1981 through 1985, returns were monitored in southeast Alaska's commercial and sport fisheries and in Ketchikan Creek, adjacent to Deer Mountain Hatchery. Marine survival, as indicated by coded-wire tag retrieval, was directly correlated to size at release and ranged from 3.6% to 5.5% for the groups of smallest and largest smolts, respectively.

KEY WORDS: chinook salmon, *Oncorhynchus tshawytscha*, Deer Mountain Hatchery, smolt size, release strategy, southeast Alaska.

INTRODUCTION

Deer Mountain Hatchery (DMH) in Ketchikan, Alaska has been operated by the Alaska Department of Fish and Game's Fisheries Rehabilitation, Enhancement and Development (FRED) Division since 1976. The hatchery was built in 1955 by the Ketchikan King Salmon Derby Committee, and the City of Ketchikan still retains ownership. Chinook salmon were reared at DMH in the 1950s and 1960s; the broodstock was from Soos Creek, Washington, but it failed to establish a self-perpetuating run in Ketchikan Creek. FRED Division began rearing spring chinook salmon at the facility in 1977; Cripple Creek, on the Unuk River, was the brood source for the years 1977 through 1981, and yearling smolts were released directly into Ketchikan Creek, adjacent to the hatchery (Figure 1).

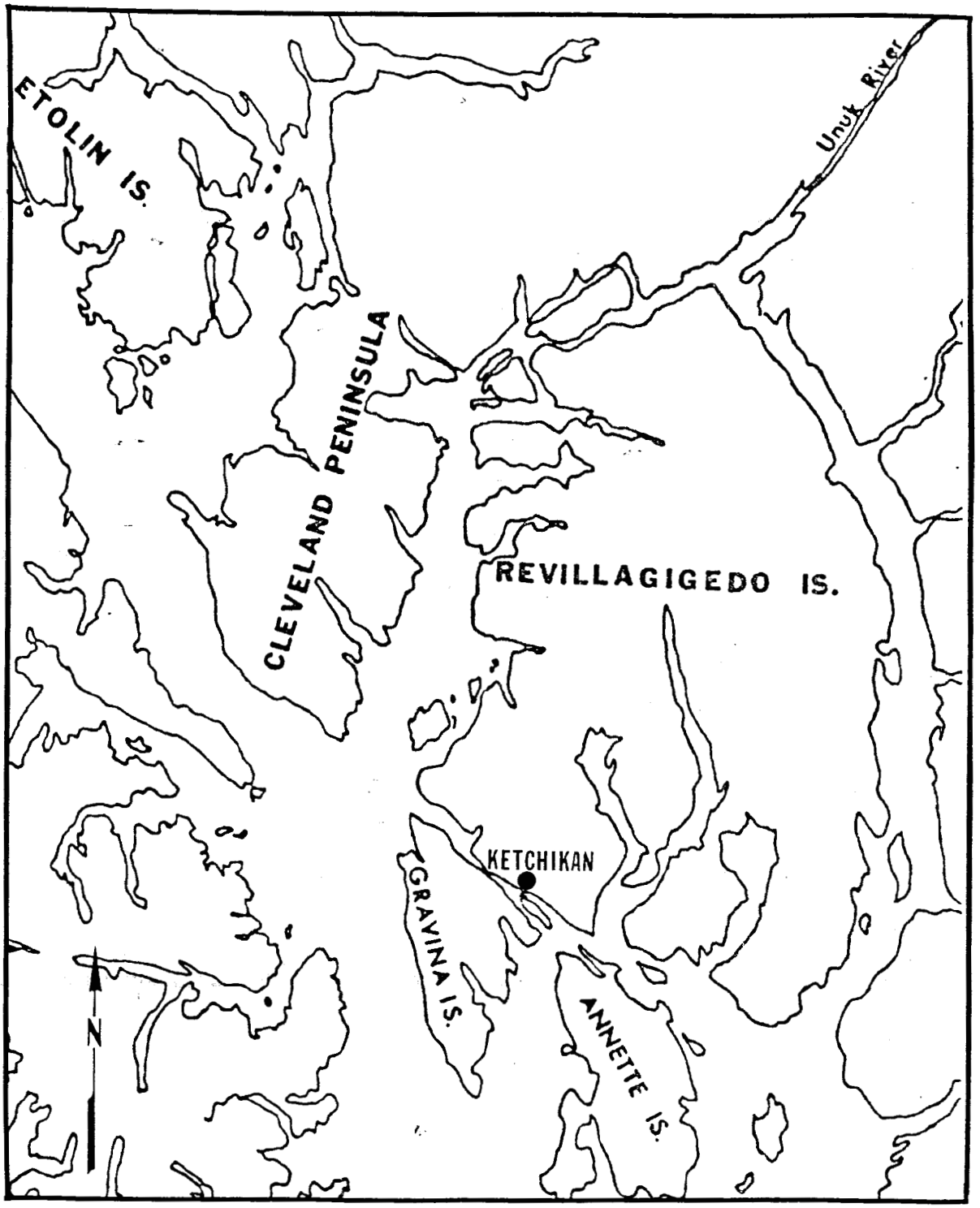

Figure 1. Map of southern southeast Alaska including Unuk River and Ketchikan, site of Deer Mountain Hatchery. Scale: 1 cm ≅ 11 km.

The 1979 brood was the first at DMH to be involved in a research project. The objective was to determine optimal smolt size at release; the marine survival percentage was the main criterion for judging the results.

METHODS

Egg Takes and Incubation

Separate gametes were stored on ice and flown by helicopter from the Cripple Creek egg-take site to Ketchikan. Four shipments were received in 1979: 4, 6, 9, and 13 August. Gamete temperatures were approximately 10°C upon receipt of the first 3 shipments. The final shipment was transported without ice and arrived at 15.5°C; however, all gametes appeared to arrive in good condition, with the exception of an unspecified portion of the first shipment that appeared water-hardened. Eggs were fertilized immediately after arrival at DMH and put in standard Heath tray incubators.

Rearing and Release

Emergent fry began rearing in Swedish-style fiberglass ponds (1.8-m diameter) inside the hatchery building. Oregon Moist Pellet II (OMP II) was fed to all fry for the entire 18-month rearing period. Three experimental groups were designated in April 1980, and rations were adjusted to produce three different smolt sizes. The group targeted to contain the largest smolts (Group C) was fed the full amount recommended by the manufacturer (hereinafter referred to as full ration), based on fish size and prevailing water temperature. Group A was fed one-third of the full ration, whereas Group B was fed two-thirds of the full ration (hereinafter referred to as one-third ration and two-thirds ration, respectively).

The majority of the fry were moved into four 4.9-m-diameter, Swedish-style fiberglass ponds behind the hatchery building in late June 1980. A portion of the full-ration treatment group remained in the 1.8-m tanks inside the building until release. All fry were tagged with coded-wire (13 January to 2 February 1981).

The fish reared outside were released directly into Ketchikan Creek through their respective tank drains. Fish reared inside were carried in buckets and released into a vacant outdoor adult-holding pond that emptied into Ketchikan Creek. All releases occurred on 15 May 1981.

Evaluation of Returns

All marine-survival estimates are based on coded-wire tag (CWT) recoveries in the commercial and sport fisheries as well as the returns to Ketchikan Creek. Tag recoveries and adult returns were monitored over a 5-year period (1981-1985).

Commercial Fishery:

The Stock Biology Group of ADF&G conducted all commercial catch sampling during the 1979 brood's return years. Port samplers were stationed at all major buying stations throughout southeast Alaska; they conducted random sampling for adipose-clipped chinook salmon. Heads recovered from these marked fish were sent to the ADF&G, FRED Division Tag Lab in Juneau for CWT extraction and reading. Final calculations of fishery contribution of the various tag codes were done by FRED Division personnel in Juneau.

Sport Fishery:

The ADF&G, Sport Fish Division conducted randomly structured creel censuses in southeast Alaska during 1984 and 1985. Expanded numbers from CWTs recovered during random sampling provide the

estimated sport fishery interception for those years. Interception estimates for return years 1981-1983 are based on the numbers of CWTs voluntarily returned by sport fishermen. No expansion is possible on these select recoveries.

A regulation allowing sport fishermen to keep adipose-clipped, undersized chinook salmon went into effect in 1983. This probably increased the documented return of age-1.2 fish in 1983, since some of that age class are less than legal size.

Escapement:

The brood source for DMH chinook salmon has been the fish returning to Ketchikan Creek since 1982. Coded-wire tag retrieval is accomplished in conjunction with adult holding and egg takes. In addition, DMH personnel conducted several "carcass patrols" in the creek to retrieve as many CWTs as possible in 1984 and 1985. This was necessary because relatively few fish returned from each of the many CWT releases at the hatchery. Expansion of the numbers of tags recovered in the Ketchikan Creek system, based on estimated total escapement, was done by the author.

At least one foot survey of Ward Creek (101-47-015), 8 km northwest of Ketchikan Creek, is conducted each year to look for stray chinook salmon. Strays also have been reported from Whitman Lake Hatchery, approximately 8 air km southeast of Ketchikan Creek.

RESULTS AND DISCUSSION

Egg Takes and Incubation

An estimated 204,000 eggs were taken from 38 females at Cripple Creek in 1979; an equal number of males was also used. Hatchery

records indicated a 78.4% survival to eyeing; of that number, 81.4% survived to emergence, giving an overall incubation survival of 64%[1/].

Each group of fry emerged at approximately 1070 CTUs during the period 26 November to 17 December. Emergent fry averaged 0.4 g in weight and 35.7 mm in length.

Rearing and Release

Although the experimental design called for three feeding rates to produce three smolt sizes at release, four smolt sizes were actually produced (Groups A, B, C, D reared outside). Data from the fifth group reared inside (Group E) cannot be compared but will be presented with the four outside-reared groups.

Table 1 summarizes growth and survival data for the experimental period, 8 April 1980 to 15 May 1981. The retarded growth rates of Groups A and B were not accompanied by reduced freshwater survival. Total survival for all groups for this period was 87.8%. The largest smolts of the 1979 brood had an instantaneous growth rate of 8.5 during approximately 13 months of rearing. By comparison, a recent yearling lot (1984 brood) had 85% survival and an instantaneous growth rate of 11.5 for the period 22 May 1985 (emergence) to 12 May 1986 (release). Improvements in commercial diets and hatchery operations are the main reasons for increased growth rates.

Coded-wire tagging was accomplished from 13 January to 2 February 1981 when fry ranged in length from 100 to 129 mm. The three planned size groups of outside-reared fry were distinguishable at

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[1/] Memo to Dave Bright from Al Kluthe, 16 June 1983, "Review of King Salmon Records at Deer Mountain".

Table 1. Freshwater growth and survival of experimental groups.

Group	Start 4-8-80		Release 5-15-81		Survival	IGR[a/]
	Wt.	No. Live	Wt.	No. Live		
A	0.99	17,886	13.44	15,893	88.9	6.488
B	0.97	17,913	16.76	15,358	85.7	7.088
C	1.06	17,496	18.01	14,982	85.6	7.046
D	1.02	16,717	24.61	15,445	92.4	7.919
E	0.94	4,858	28.94	4,065	83.7	8.525

a/ Instantaneous growth rate, $\frac{1}{t}$ Ln $(\frac{\text{end weight}}{\text{begin weight}})$. 1000

Where t = time in days; beginning and ending weights are in grams.

that time; fortunately, a fourth tag code was used on half of the large fry that were rearing in a separate tank, and this enabled the designation of a fourth group at time of release. Table 2 summarizes pertinent CWT data.

Furunculosis, *Aeromonas salmonicida*, was diagnosed on three occasions during rearing in at least part of the population; TM-50 was administered to all fish in their feed from 12 to 21 August 1980. Group C was again treated in October 1980; and Groups B, C, and D were treated from 10 April to 8 May 1981, receiving medication in their feed on their normal feeding schedule (every other day). The severity of disease in Group C may have contributed to their less-than-expected growth rate, which differentiated them as a discrete size at release.

Fish culturists involved with rearing in 1980 and 1981 generally felt that Group A, which was receiving one-third ration, was in poor condition by early 1981. Hatchery personnel described them as "runts" and "sickly-looking". They also noted they seemed very thin, and there was also an abundance of frayed fins in this group. Concern for their condition led to a feed-rate modification, and all 1979 brood fish were put on two-thirds ration from 5 March 1981 until release in mid-May.

Rearing densities differed for the four experimental groups. Final densities ranged from 12 kg/m^3 for Group A (one-third ration) to 21 kg/m^3 for Group D (full ration). Many studies linking rearing density to fish health and performance have been reported in the literature, but specific effects of various densities are mostly unknown for *Oncorhynchus* spp. Unfortunately, the range of densities in this study may have introduced a second variable, the effect of which cannot be determined.

Jumping and silvering of fish in early May was taken as evidence of smoltification. Release occurred without incident between 1300 and 1600 hours on 15 May. Table 3 summarizes release data.

Table 2. Coded-wire tagging data and size at release.

Group	Code	Number tagged	Dates	Length at tagging (mm)	% retention[a/]	Valid tags released
A	04-20-40	15,935	1-28 to 1-30	100	99	15,734
B	04-20-39	15,509	1-23 to 1-27	110	99	15,204
C	04-19-45	15,404	1-20 to 1-22	114	97	14,533
D	04-19-43	15,824	1-13 to 1-16	115	93	14,364
E	04-19-17	4,081	2-2	129	94	3,821

a/ Determined from a sample of 500 fish per code, just prior to release - 101 to 119 days after tagging.

Table 3. Release data 1979 brood chinook salmon.

Group	CWT code	Wt.	Fork length	K[a/]	Number released	Final density (kg/m^3)
A	04-20-40	13.44	105.96	1.130	15,893	12.0
B	04-20-39	16.76	115.73	1.081	15,358	14.4
C	04-19-45	18.01	114.19	1.210	14,982	15.1
D	04-19-43	24.61	128.75	1.153	15,445	21.3
E	04-19-17	28.94	132.19	1.253	4,065	20.0

a/ Condition factor: $\frac{W}{L^3} \cdot 10^5$

Evaluation of Returns:

A summary of all returns from the 1979 brood is presented in Table 4. The total known survival of 4.28% is the highest of all DMH chinook salmon releases from which returns have been completed at this time: 1977 brood, 1.25% (Denton 1985a); 1978, 3.91% (Denton 1985b). Total fishery interception for the brood year was 44%; the interception rate of adults only (ages 1.2, 1.3, 1.4) was 57%. The DMH chinook salmon are intercepted throughout southeast Alaska; a detailed account for each year is contained in annual evaluation reports (Ward and Denton 1983; Ward 1984; Denton 1985a; Denton 1986).

Experimental Groups:

Groups A-C were released at ≦18 g and had survivals ranging from 3.55% to 3.76% (Table 5). Group D was released at approximately 25 g and had over 5% survival, or approximately 1.5 times better than the three smaller groups. Group E was released from the inside tanks at approximately 30 g; fish in this group also had excellent survival; however, the differential treatment and the small number of fish released preclude any further comparison.

The general trend of increased survival as smolt size increased is shown in Figure 2. Group C may have varied from the general trend because of the apparent greater disease incidence it suffered, or because the variation is only an artifact of sampling errors in respect to group smolt-size differences at release or in estimating survival to adult.

Average lengths of adult males returning to Ketchikan Creek are also given in Table 5 and plotted in Figure 3. Size at release does not appear to be correlated with size at return.

Table 4. Total known marine survival of 1979 brood chinook salmon released from DMH.

Year	1981	1982	1983	1984	1985	
Age at return	1.0	1.1	1.2	1.3	1.4	Total
Commercial Fishery	0	7	544	437	15	1003
Sport Fishery	0	3	57	117	51	228
Escapement	224	448	273	531	104	1580
Total[a/]	224	458	874	1085	169	2,811
Percent Return	0.34	0.70	1.34	1.65	0.26	4.28

a/ Total return for year.

Table 5. Average length[a/] and percent return of Deer Mountain Hatchery chinook salmon from experimental groups, 1979 brood.

RELEASE		RETURN										
		Age-1.0		Age-1.1		Age-1.2		Age-1.3		Age-1.4		Total
Group	Weight (g)	% return	Length (mm)	% return	Length (mm)	% return	Length (mm)	% return	Length (mm)	% return	Length (mm)	% return
Reared Outside												
A.	13.44	0.17	199	0.37	435	1.08	600	1.69	803	0.24	853	3.55
B	16.76	0.24	210	0.96	431	0.94	723	1.31	823	0.30	838	3.75
C	18.01	0.30	207	0.51	458	1.31	653	1.45	829	0.19	955	3.76
D	24.61	0.57	218	1.03	468	1.66	706	1.86	818	0.33	890	5.45
Reared Inside												
E	29.58	0.68	238	0.31	498	2.53	-	2.68	824	0.15	942	6.35

[a/] All lengths are MEFT, male returns to Ketchikan Creek.

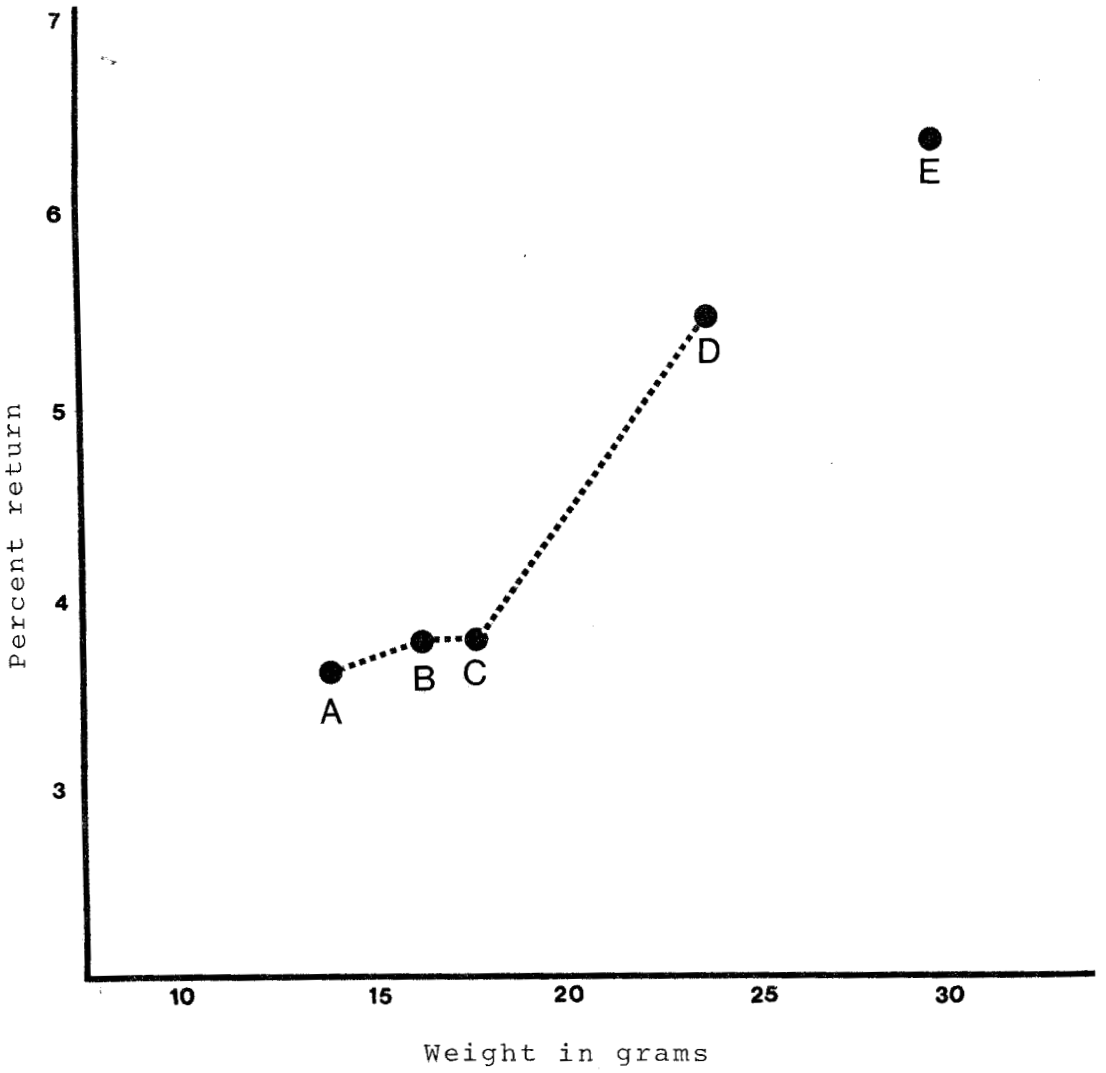

Figure 2. Smolt size at release and percent return, 1979 brood.

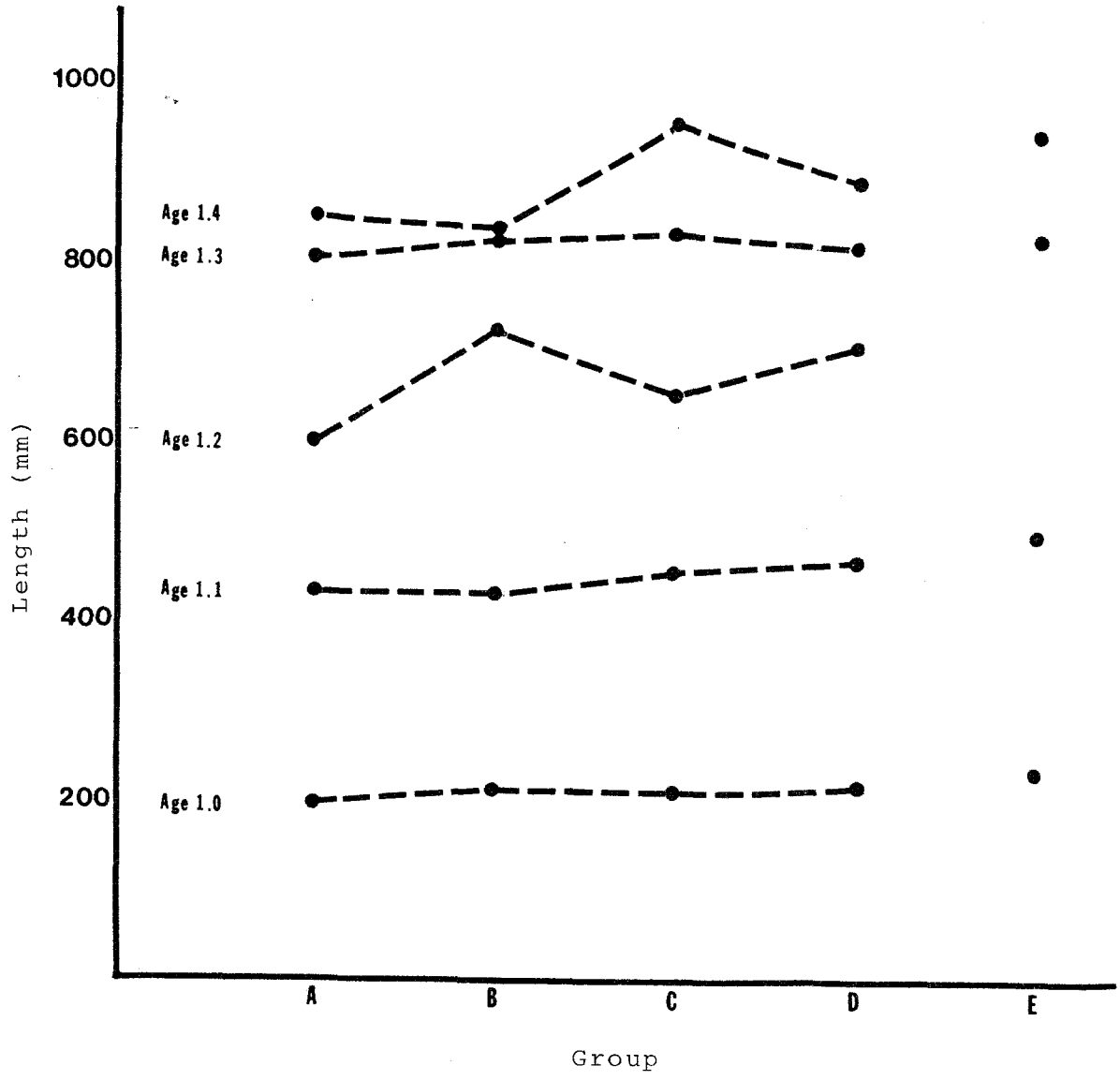

Figure 3. Length of males returning to Ketchikan Creek from experimental groups of the 1979 brood.

Chinook salmon biologists often have been concerned that the release of large smolts will produce an increased incidence of early male maturity (Novak 1982). Age-1.0 returns of the 1979 brood appeared to support this concern.

However, total subadult returns (ages 1.0 plus 1.1) ranged from 15% to 32% of total returns from each smolt group (Table 6) and did not appear to be correlated to size at release. Twenty-four percent of all returns from the 1979 brood year were early maturing males; the standard assumption used for planning purposes at DMH is 22%. Unuk River chinook salmon were used in another size-at-release study at the National Marine Fisheries Service's Little Port Walter facility. Size at release did not affect the rate of early male maturity (Hard et al. 1985). Subadult returns were approximately 15% of total returns; size at release ranged from 64 to 83 g.

One 1979 brood DMH chinook salmon gained notoriety in winning the 1984 Ketchikan Little League Salmon Derby. The fisherman received $3,400, including $400 contributed by ADF&G employees for the largest tagged DMH fish entered in the Derby. The winning fish was 24.2 kg (53 lb 6 oz).

Documented straying for the 1979 brood was minimal, as with all DMH chinook salmon. Six strays were reported in 1984 (age 1.3): four from Whitman Lake Hatchery and two from Ward Creek (both sites are in the same community as DMH); Groups B, C, and D each had two strays.

Conclusions

The technique of withholding feed to produce various sizes of chinook salmon smolts was not totally satisfactory. Group A had the smallest smolts and did not appear healthy. All experimental groups were treated for furunculosis; surprisingly, Group A required only one treatment; while Groups B and D were treated twice, and

Table 6. Percentage of return as subadult age classes (1.0, 1.1).

GROUP	PERCENT
A	15
B	32
C	22
D	29
E	16

Group C, three times. It is therefore probable that reduced feed was not an important precipitating factor for the disease. Overall rearing survival was not correlated with disease incidence or with decreased rations.

Marine survival appeared to be strongly correlated with size at release. A second variable, density during freshwater rearing, may have exerted some influence. It is generally believed, however, that low densities are more beneficial for fish health and marine survival (Fagerlund et al. 1983; Refstie 1977). In the present study, large smolts reared to 21 kg/m^3 density had marine survival 1.5 times greater than small smolts whose density did not exceed 12 kg/m^3. Clearly, the advantage of large size at release outweighed any detriment imposed by crowding of the large fish. Each of the four groups (each group occupying one pond) contained equal numbers of fish. Therefore, density in terms of numbers of fish per pond was similar for all four groups.

The fifth group of the 1979 brood, in which 4,065 smolts were reared inside the building and released at approximately 30 g, had the best survival of any 1979 group. However, the small number of fish involved and the differential treatment do not allow for comparison with other groups. Additional release studies of 30-g or larger smolts should be implemented at DMH.

ACKNOWLEDGMENTS

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